

Posture Alignment and the Surrounding Musculature

An Honors Thesis (HONR 499)

by

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Abstract

It is reported that musculoskeletal conditions are the most common reason to seek medical consultations in the U.S., therefore, it is important to find the underlying cause of the pain and discomfort that society is experiencing (Osar, 2012). When examining the musculoskeletal system and how it is interconnected with the nervous system, it can be found that society as a whole experiences dysfunction from simple everyday movement patterns that can lead to injury and pain (Page, 2014). One's posture is critical to health and wellness, and activities of daily living as the core and the spine are crucial in determining how the rest of the body moves and functions. The position of the spine is determined by the neuromuscular system surrounding the spine and along the kinetic chain which affects an individual's movement patterns. Evidence indicates any small deviation along the kinetic chain will result in change to the neuromuscular system and the increased risk of injury or pain. Because posture and the risk of injury or pain are correlated, it is critical to be able to differentiate between good posture and the different types of posture deviations.

The purpose of this paper is to define good posture and provide an understanding of the underlying causes of postural deviations. An analysis of the four types of postural deviations – lordosis, kyphosis, flat back, and sway back will provide the ability to recognize the common types of postural deviations and provide a structured approach to correcting each type of postural deviation.

Acknowledgments

I would like to thank Mary Winfrey-Kovell for advising me through this project. Her help and feedback through this long project was only a small fraction of the guidance that I have received during my college career.

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Process Analysis Statement

I started this project by conducting a lot of research. I read dozens of journal articles and books about the spine, posture, the neuromuscular system, and different rehabilitation techniques. I compiled the information that I had read about into this project. After conducting my initial research, I categorized the information that I thought would be useful for my project into the different sections that I thought I would use in the final product. From there, I began to write section by section leaving the correction exercises for each posture deviation for last. After I had all of the background information completed and a general overview of each posture deviation written, I decided that it would be beneficial to have pictures for each of the exercises I wanted to include. This way, if someone was at home and wanted to perform these exercises, they would have both words and pictures to follow. I added the pictures to my project last.

The process of creating the project was harder than I expected. I thought that I narrowed my topic down pretty well when I had met with the Honors College to get it approved. However, when I first started, I felt very overwhelmed by the amount of information that is out there and all of the different things that I could include in my project. After compiling the information down to a more general overview, I was able to then see a clear direction for my project. I still feel like I could add so much to this project to fully explain in more depth muscle imbalances and how they affect our posture. Once I began to create correction programs and take pictures for each exercise, I began to enjoy the process much more. I knew that these things I was learning and writing about would be beneficial to my future career as a physical therapist.

Posture Alignment and the Surrounding Musculature

Introduction

Research shows that an increasing number of people are complaining about back pain and have begun going to physical therapy for pain and injury. One the leading causes for this is related to the inability of individuals to move properly. In the United States alone, there are approximately 157 million visits per year to the doctor's office for treatment of musculoskeletal conditions costing about \$215 billion per year (Osar, 2012). Since 1971, the obesity rate in 18 to 64 year olds has more than doubled (Osar, 2012). Finally, the most reported causes of chronic disabilities among working individuals is arthritis and musculoskeletal conditions (Osar, 2012). These issues can be related to the fact that society has moved from a production society where jobs required physical labor to a service society where jobs include sitting in front of a computer screen, sitting in meetings, and sitting on the phone. If all an individual does is sit at work and then sits when they get home, they will not be equipped to do the dynamic movements the body requires when they try to do something that requires a more complex movement than sitting. By attempting to do these movements in which the center of gravity is changed, the individual experiences injury or pain because the body has not been performing those functional movements as often as necessary (Osar, 2012).

Functional movement patterns and dysfunction begin from early stages in life. Throughout one's lifetime, there are essentially three things that cause dysfunction in movement: poor neurodevelopment, injuries, and learned behaviors (Osar, 2012). Approximately one third of children never develop optimal nervous system dysfunction resulting in the other two-thirds of the population becoming more likely to develop pain and

dysfunction later in life due to poor neurodevelopment (Osar, 2012). Injuries and the healing process of an injury can also affect one's function. If left untreated or healed improperly, an injury will cause compensation in other parts of the body and, therefore, lead to dysfunction. Finally, learned behaviors can also lead to dysfunction. Learned behaviors include everything from crawling as a baby to how one sits in the chair during school to how one performs the daily functions of their jobs as adults. If one is constantly sitting in a slouched position, that will become the new normal or default pattern, ultimately, changing the function the muscles were intended to carry out (Osar, 2012).

Posture is essential to everyday life. The way an individual holds the body determines every movement pattern throughout their activities of daily living, their limitations, and how likely they are to become injured or experience pain. Infants are born with perfect posture and movement patterns. However, with age the joints, bones, and muscles grow and change, therefore, affecting posture. Then, as adults, the process of activities of daily living have changed the neuromuscular system resulting in muscle imbalances which are the main contributor to poor posture. Because posture is so important to an individual's mobility, it is essential to be able to differentiate between good posture and the different types of posture deviations. Only then, can correcting that posture through exercise be addressed.

Postural Stability and Good Posture

Good posture should accomplish three things: be ergonomically advantageous while standing or sitting, be mechanically effective while moving, and be supportive for the normal function of internal organs (Page, 2014). Another source indicates that biomechanics and

neuromuscular function play a role in posture. These two systems must work together to position the body in a way that meets its demands whether that be to prevent movement, coordinate movement, safely load spinal segments or conserve energy (Claus, 2014). Posture can look different in the sitting position compared to the standing position and can be assessed by observing a patient in the frontal plane, sagittal plane, and transverse plane (Claus, 2014; Czaprowski, Stoliński, Tyrakowski, Kozinoga, and Kotwicki, 2018; Page, 2014). When evaluating posture, good body posture would be described as having lordosis in the cervical and lumbar spine and having kyphosis in the thoracic spine as demonstrated in Figure 1. The head is in a position in which the eyes are level and the chin is just above the sternum. The pelvis has a slight anterior incline while the lower limb joints remain neutral (Page, 2014).

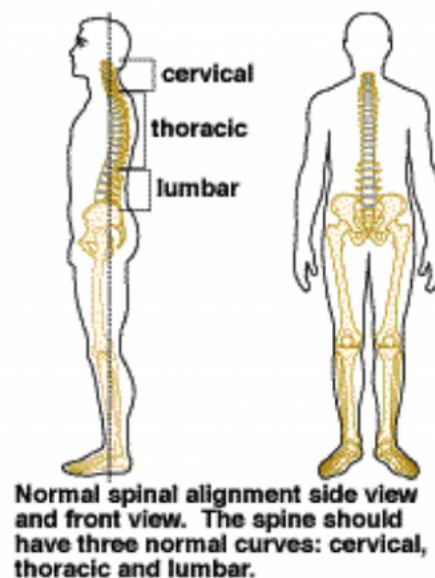


Figure 1. The spinal alignment in good posture. Stryker, S. (2013, April 3). Cervical Posture and Stabilization. Retrieved from <https://lifesworkpt.com/2013/04/cervical-posture-and-stabilization/>.

Because the primary functions of muscles are controlled by the CNS, often dysfunction in the muscles lead to observable changes in muscle function (Claus, 2014). Therefore, it is

essential to look at the body carefully in order to determine the origin of pain or muscle imbalance. Muscle function changes can be observed through asymmetry, contour, shape, or tone, as well as the position of joints and limbs (Czaprowski, 2018).

The Kinetic Chain

Not only are the different parts of the spine interconnected, but so is the whole body. The position of the foot can affect the position of the spine due to the kinetic link principle (Brumitt, 2010). Ellenbecker and Davies describe the kinetic link principle as the way the human body works as a series of interrelated links or segments. The movement of one segment affects the proximal and distal segments to the first segment (Ellenbecker and Davies, 2001). For example, the knee is affected by the hip, foot and ankle. If the hip is weak, it could become internally rotated which would also cause the knee to become internally rotated and the foot to be everted. It is important that all of the interconnected joints of the body are working together synergistically to produce a movement. If the different joints and muscles do not work together synergistically, injury could occur due to the dysfunctional movement pattern (Brumitt, 2010).

Muscle Tightness and Muscle Weakness

Some muscles in the body are more prone to tightness/shortness whereas other muscles tend to develop weakness/inhibition. This is important because it can be seen in all of the posture deviations that tightness or weakness in one muscle can affect the whole kinetic chain. The muscles that have a tendency to be tight/short are the gastrocnemius, soleus, hip flexors (rectus femoris, iliacus, psoas, tensor fascia lata), adductors, hamstrings, erector spinae,

quadratus lumborum, piriformis, upper trapezius, levator scapulae, pectoralis major and minor, sternocleidomastoid, short deep cervical extensors, and upper extremity flexors (Liebenson, 2007). The muscles that are more prone to being weak/inhibited are the tibialis anterior, vastus medialis, gluteus maximus, gluteus medius, gluteus minimus, abdominals, lower and middle trapezius, serratus anterior, deep neck flexors, scalenes, and upper extremity extensors (Liebenson, 2007).

When rehabilitating, it is important to address muscle tightness before addressing muscle weakness. The reason for this is if a muscle is tight, then strength training will reinforce that faulty movement pattern due to the tightness. However, if the muscle tightness is released first, then the muscles are relaxed and lengthened which will allow for less joint stress and easier isolation in the target area. The only exception to this rule is if the muscle that is weak is also lengthened. In this case, strengthening can begin right away. Stretching this muscle would cause it to become even longer and weaker, therefore, being more harmful than beneficial (Liebenson, 2007).

Muscle tightness must be addressed when correcting posture because tight muscles can lead to injury. If muscle tightness is present, it is an indication of muscle imbalance which indicates there are also weak muscles. Muscle imbalance can lead to joint dysfunction, poor movement patterns, early fatigue, and pain before leading to injury (Page, 2014).

Understanding Muscle Imbalances and Its Affect on Misalignment

Muscle imbalances must be assessed in order to fully understand the causes of misalignment and dysfunction. Vladimir Janda, a neurologist and physiotherapist, developed

what is known today as the Janda Approach, a way to treat and rehabilitate the musculoskeletal system of patients based on the idea that the central nervous system and the motor system are connected through what is known as the sensorimotor system (Page, Frank, and Lardner, 2014). Because of this, any change that the body experiences also affect the other areas of the body. Another model was developed by Panjabi who breaks it down into three interconnected systems: the skeletal system, the muscular system, and the central nervous system (CNS). If any one of these components experienced a dysfunction it would lead to compensations from another system developing as a normal adaption, a long-term adaption by one or more of these systems, or injury to one or more of the systems becomes a pathological adaption (Claus, Hides, Moseley, and Hodges, 2014; Page, 2014).

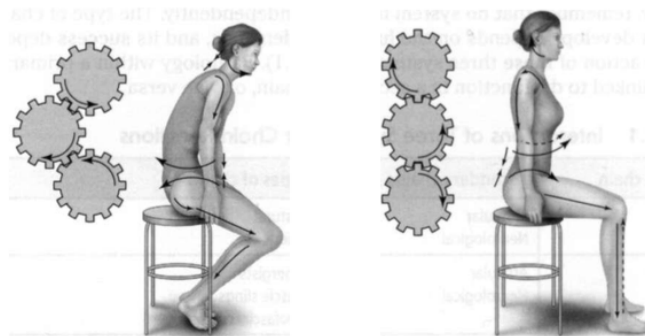


Figure 2. Cogwheel Chain Mechanism of Poor Posture. Page, P., Frank, C. C., & Lardner, R. (2014). Assessment and treatment of muscle imbalance: The Janda approach. Champaign, IL: Human Kinetics.

Janda went on to use the ideas that the body is connected by different chains – articular, muscular, and neurological – and these chains can help a clinician determine where the pain originates, how it has affected all connected parts of the body, and the best way to approach rehabilitation (Page, 2014). For example, with relation to posture, the regions of the spinal column are connected by the vertebral system and when there is a change in one of the

regions, it causes the other regions to shift. This can be described by the *Brugger sitting posture* which uses cogwheels to relate the point as seen in Figure 2 (Page, 2014). Poor sitting posture causes a posterior tilt in the pelvis which causes a chain of reactions up the spinal column. The normal lordosis of the lumbar spine (the lowest cogwheel) is reduced causing a reduction in the normal kyphosis of the thoracic spine (the middle cogwheel). This also causes the head (the top cogwheel) to move into a forward position (Page, 2014).

Muscle Imbalance Classifications

There are three stereotypical patterns of muscle imbalance that are associated with chronic pain. They are the upper-crossed syndrome, the lower-crossed syndrome, and the layer syndrome, and are characterized by patterns of muscle weakness and tightness (Page, 2014).

Upper-crossed syndrome is synonymous with shoulder girdle crossed syndrome. It is characterized by tightness in the upper trapezius, levator scapulae, pectoralis major and pectoralis minor as well as weakness in the deep cervical flexors and the middle and lower trapezius. These muscle imbalances lead to joint dysfunction at the atlanto-occipital joint, C4-C5 segment, cervicothoracic joint, glenohumeral joint, and T4-T5 segment (Page, 2014). The postural changes that are associated with this syndrome are forward head posture, increased cervical lordosis, and thoracic kyphosis. These changes in posture lead instability at the glenohumeral joint due to the weakness of the serratus anterior causing the levator scapula and upper trapezius to increase activation to try to uphold glenohumeral centration (Page, 2014).

Lower-crossed syndrome is synonymous with pelvic crossed syndrome. It is

characterized by tightness in the thoracolumbar extensors, iliopsoas, and rectus femoris as well as weakness of the deep abdominal muscles, gluteus maximus, and gluteus medius. These muscle imbalances lead to joint dysfunction at the L4-L5 and L5-S1 segments, SI joint, and hip joint. The postural changes that are associated with the syndrome are anterior pelvic tilt, increased lumbar lordosis, and knee hyperextension. Deep stabilizing muscles become inhibited causing the activation of superficial muscles to stabilize the spine. The hamstrings then become tight as they are compensating for the anterior pelvic tilt and inhibited gluteus maximus. These compensations create a chain reaction up the spine to maintain stability – the increased anterior pelvic tilt increases the thoracic kyphosis and cervical lordosis (Page, 2014).

Lastly, layer syndrome is synonymous with stratification syndrome and is a combination of upper-crossed syndrome and lower-crossed syndrome: which is characterized by a tight cervical erector spinae, upper trapezius, levator scapulae, thoracolumbar erector spinae, and hamstrings. It is also characterized by weak lower stabilizers of the scapula, lumbosacral erector spinae, and gluteus maximus (Page, 2014).

Causes of Misaligned Posture and Pain

Muscle imbalances can cause pain or pain can cause muscle imbalances. Either way, these two factors lead to more chronic issues. Lifestyle is often the main contributor to muscle imbalance. Janda believed that stress, fatigue, lack of movement through regular physical activity, and lack of variety of movement leads to muscle imbalance. Lack of variety of movement leads to repetitive movement that therefore becomes ingrained in the motor cortex

as the new “normal.” This idea can be reinforced by Lund and colleagues’ pain adaption model seen in Figure 3 (Page, 2014).

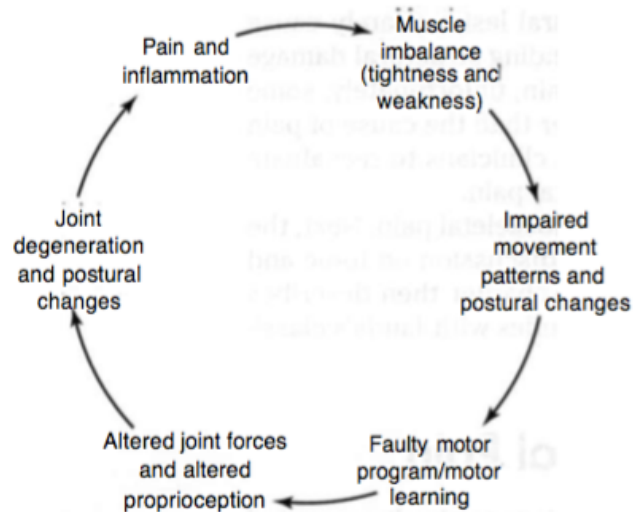


Figure 3. The Chronic Musculoskeletal Pain Cycle Presented from a Neurological Perspective. Page, P., Frank, C. C., & Lardner, R. (2014). *Assessment and treatment of muscle imbalance: The Janda approach*. Champaign, IL: Human Kinetics.

Muscle imbalance is caused by specific muscle groups becoming tight and other muscle groups becoming weak. This leads to impaired movement patterns and postural changes as a result of pain. The protective nature of the muscles in the body recognize pain in a certain area and then work to produce a compensatory response to try to alleviate that pain. However, this leads to a decreased range of motion and altered movement patterns. The repetition of these new movements becomes ingrained in the motor cortex due to the nature of motor learning. The faulty movement becomes the new “normal” movement. The altered movement pattern changes the normal movement patterns of joint stress, therefore, changing the distribution of stress on the joint capsules. This can cause wear and tear on the joints and lead to degeneration. Ultimately, the degeneration of the joints will cause changes in posture because

the body can no longer hold itself as is normally would. Overtime, the altered posture would cause joint pain and inflammation, leading to chronic pain. Then, the cycle repeats itself again and again (Page, 2014).

Lifestyle's Affect on Posture

From birth, humans were designed with a spine and pelvis that were perfectly level with the correct amount of curvature to allow the body to move efficiently and safely. However, the lifestyle of humans can change natural positions over time. Most people sit for long hours every day in a slumped position and over time, the neuromuscular system becomes programmed to that position and automatically defaults into that position (Hey et al., 2017). This can cause the spine and pelvis to also change from their natural position to adapt to the new one that is being constantly repeated. Multiple studies have been conducted to examine the amount of time each day individuals spend sitting. Win et al. conducted a study in Southeast Asia and found that on average, a person spends six hours a day sitting, with a third of the people spending closer to eight hours a day sitting (Win et al., 2015). Matthews et al. conducted a study in the United States and found that most children and adults spend 7.7 hours a day, or 55% of their waking time, sitting. Most reported that they spent these hours in front of a television or a computer screen (Matthews et al., 2008). Ekblom-bak et al. conducted a study in Sweden and found similar results (2015). On average, the adult participants spent 60% of their time sitting and 40% of their time in activities involving standing (Ekblom-Bak et al., 2015). It can be concluded that on average more than half of a person's waking hours are spent sitting, making it the predominant posture (Hey et al., 2017).

This issue does not just exist in adults when they get a job. This is an issue that begins from early childhood. One of the most common diseases among children is postural disorders and spinal deformities (Mitova, 2015). Reasons for this are reduced motor activity, prolonged sitting in front of the computer from early childhood, bad posture at school, heavy backpacks, inappropriate diet, increased traumatic injuries, congenital spinal anomalies, and fewer hours of participation in physical activities. Because the spinal musculature is not being exercised the way it should be, it becomes more susceptible to fatigue, which leads to compensation and finally, bad posture (Mitova, 2015).

Other Factors Affecting Posture

Muscle imbalances and pain are the main reasons for posture deviations. However, many other factors, such as congenital and non-congenital can affect posture. Congenital factors involve the body itself. There can be structural or anatomical conditions which include scoliosis in all or part of the spine, discrepancy in the length of the long bones in the upper or lower limbs, extra ribs, extra vertebrae, or increased elastin in tissues which decreases the rigidity of ligaments. Age can also affect posture. As individuals grow older, posture changes to accommodate for growing bones, muscles, etc. (Myers, 2009). Aging produces the issue of developing sarcopenia, the loss of skeletal muscle associated with aging. On average, by the age of 65, sarcopenia affects 25% of the muscles' function and can grow to 40% over the course of a lifetime (Swain, 2014). Other biological factors experiencing a decline due to age are: the function of α -motor neurons, motor cortex activity, motor unit recruitment, bone density and

joint flexibility. All of these components can lead to the development of postural dysfunction due to joint restriction, bone density loss, muscle atrophy or loss (Swain, 2014).

Physiological changes, most of which are temporary, can also affect posture. These include a change in posture when an individual feels alert and energized compared to when an individual is fatigued and tired, when an individual feels pain or discomfort and tries to adopt different positions to minimize it, and when pregnancy causes a woman to adapt to fetal development. Some other factors affecting posture are pathological. Illness and disease affect posture especially when bones and joints are involved. Again, pain can lead to compensation in which posture is affected. Misalignment during the healing of fractures can also sometimes cause changes in posture. Conditions in which muscle tone is increased or decreased, or conditions in which osteoporotic changes are observed, are also considered pathological factors affecting posture.

Non-congenital factors affecting posture include occupation, recreation, the environment, the culture, and emotion. Occupational factors are considered due to the variety of jobs humans perform. Some sit at a desk all day viewing a computer screen and others are up and moving performing manual labor. Recreational factors include the type of physical activity they participate in – sports, regular exercise, or no sports or exercise at all. Environmental factors, for example, can be when someone feels cold they adopt a different posture than when they are feeling warm. Culture also plays a role in posture too. Some people grow up in cultures when sitting cross-legged or squatting is the most common form of sitting. These people will have a completely different posture than those who grow up in a culture sitting in chairs. Emotional factors that affect posture can be an individual's mood – grieving or

angry, or the way they feel about certain experiences, such as the fear of pain resulting in a individual adopting a protective posture to avoid the pain (Myers, 2009).

Other non-congenital factors caused by poor posture are forward head posture and rounded shoulders, which are associated with all four of the clinically identified posture deviations. Forward head posture is addressed in almost all of the corrective exercises that are specific for each individual posture deviation. Just like any other posture deviation in the body, it is caused by a series of tight and weak muscles that are creating an imbalance. In forward head posture, the tight muscles are the anterior and middle scalenes, the sternocleidomastoid, the sub-occipital muscles, and the upper cervical extensors. The weak muscles are the deep neck flexors and the lower cervical extensors. Forward head posture is the result of repeated poor postural habits, creating a new normal that is in fact not normal at all. If left untreated, a forward head posture can cause muscular tightness, premature joint degeneration, nerve impingement, and disc issues. Rehabilitation exercises should focus on loosening the tight muscles and strengthening the weak ones (Wong, 2019).

Rounded shoulders are caused by a muscle imbalance between the muscles that pull the shoulders forward and the muscles that pull the shoulder backward. The muscles pulling the shoulders forward become tight and shortened while the muscles pulling the shoulders backward become lengthened and inhibited. The tight muscles include the pectoralis major and minor, subclavius, subscapularis, latissimus dorsi, teres major, upper trapezius, and serratus anterior. The inhibited muscles are the mid- and lower trapezius, rhomboids, posterior deltoid, and rotator cuff. To correct the position of the shoulders, the tight muscles need to be stretched and the inhibited muscles need to be strengthened (Wong, 2016a).

Analysis of the Four Types of Postural Deviations

Lordosis

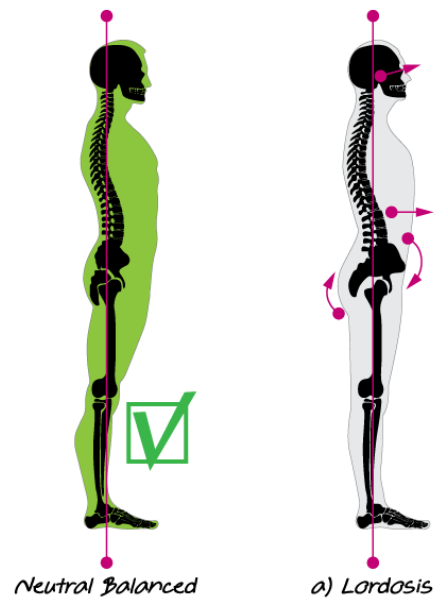


Figure 4. Neutral Spine compared to Lordotic Spine. Hui, A. (2018, September 28). Take these Small Steps to Improve your Posture in the Office. Retrieved from <https://www.olympiabenefits.com/blog/good-posture-why-is-it-important-how-can-you-improve-in-the-office>.

To recognize lordotic posture, it is important to identify the position of the body structures. Figure 4 compares a neutral spine with a lordotic spine. In lordosis, the head remains neutral or is moved forward. If the head is neutral, the cervical and thoracic spine maintain their normal curve with the cervical spine being convex anteriorly and the thoracic spine being convex posteriorly. If the head is moved forward, the spine exhibits excessive kyphosis. The lumbar spine is hyperextended causing the pelvis to be anteriorly tilted. The hip joints become relatively flexed while the knee joints are hyperextended and the ankle joints are plantar flexed (Czaprowski, 2018).

The position of the different body parts affects which muscles are lengthened, shortened, hypoactive and hyperactive (Table 1). The psoas muscle becomes shortened and hyperactive which pulls the pelvis forward into an anterior tilt and causes the excessive curve in the lumbar back. Other tight muscles include the erector spinae, quadratus lumborum, and latissimus dorsi. The weak muscles include the internal obliques, transverse abdominis, and rectus abdominis (Czaprowski, 2018).

Muscles in Lordotic Posture				
Muscle	Lengthened	Shortened	Hypoactive	Hyperactive
Abdominals	x			x
Erector spinae		x	x	
Gluteal muscles	x		x	
Hamstrings	x			x
Iliacus		x	x	
Latissimus dorsi		x	x	
Pectoralis major and minor		x		x
Psoas		x		x
Quadratus lumborum		x	x	
Rhomboideus major and minor	x		x	
Scaleni		x		x
Sternocleidomastoid		x		x
Suboccipital		x		x
Trapezius		x		x

Table 1. Functional Characteristics of Muscles in the Lordotic Posture.

Most commonly, lordosis is present in those who sit a lot, particularly those who have a desk job. To compensate for the excessive lordosis of the lower back, it is common for those with lordosis to develop a hunchback (Wong, 2016a). This means there is excessive kyphosis of the upper back and the head is moved forward (Wong, 2019). Lordosis is also common during pregnancy or in someone with excessive belly fat. The extra weight in the abdominal region pulls the lumbar spine into excessive extension (Wong, 2017a).

To check for lordosis of the lumbar spine, the body can be viewed from the sagittal plane, or the side. If the lower back has a significant arch in it, then lumbar lordosis is present. Another way to check for lordosis is to lie face up with your legs completely straight. Place the hands under the lower back. If the entire hand fits under the back easily, this indicates lumbar lordosis. Normally, the curve of the back is not big enough to fit the hand under it. In an individual with lumbar lordosis, it is important to not arch the back more than it already is. It is also important to be aware of sleeping positions. Lying face down on the stomach can increase the arch in the lower back. Therefore, to reduce lumbar extension, sleep lying face up on the back with a pillow under the knees (Wong, 2017a).

One of the biggest problem areas for someone with lordosis is the pelvis being anteriorly tilted (Claus, 2014; Wong, 2017a). This means that the muscles that are attached to the hips are tight and are pulling the pelvis forward. The muscles that are tight and need to be stretched are the erector spinae, quadratus lumborum, latissimus dorsi, and psoas. The muscles that are weak and need to be strengthened are the abdominal muscles and gluteal muscles (Wong, 2017a).

Corrective Exercises for Lordosis

1. Releases and Stretches

Goal: to loosen the tight muscles that are pulling on the pelvis

Exercise 1: Lower back release

Lie on your back on the floor with your knees bent and feet flat on the floor. Place a massage ball or ball of a similar size under your lower back. Your target muscles are the quadratus lumborum, erector spinae, and



latissimus dorsi. Relax your body weight over the ball and move your body in a circular motion to target those areas. Be sure not to roll the ball right on your spine. Cover all the muscles on both sides of the spine for two minutes.

Exercise 2: Prayer pose

Kneel on the floor and bend at your hips as if trying to place your forehead on the ground in front of you. Reach your arms out over your head as far as you can. Sit back into your hips. You should feel a stretch in your lower back. Hold for 30 seconds, release, and repeat three times.



Exercise 3: Latissimus dorsi/quadratus lumborum stretch

Stand with your feet shoulder width apart and stretch your arms out over your head clasping your hands together. Laterally flex to one side. You should feel a stretch on the side of your body and lower back. Hold for 30 seconds, release, and alternate sides. Repeat three times on each side.



Exercise 4: Hip flexor stretch

Get into a lunge position with your back knee straight and your front knee bent. Keep your head, neck, and spine in a straight line. Tuck your tailbone underneath you by rotating your pelvis. You should feel the stretch in the front of the hip of the leg that is back. Hold the stretch for 30 seconds, release, and alternate sides. Repeat three times on each side.



2. Strengthening Exercises

Goal: to strengthen the abdominal muscles and gluteal muscles

Exercise 1: Dead bug

Lay on the floor on your back. Bend your knees and hips to 90°. Slowly lower one of your legs to the ground while keeping your knee bent. Throughout the whole movement, you want your lower back to be touching the



ground. If at any point it comes off the ground, stop and go back to the starting position. Alternate legs and repeat 10 times on each side.

To progress this exercise, you are going to do the same thing, but this time, when you lower your leg to the ground, you are going to straighten it too. This creates a longer lever and engages more of your abdominal muscles.

To progress even further, assume the same starting position. Put your arms straight up in the air in front of you. Brace your abdominals and make sure your lower back is in contact with the floor. At the same time, lower and straighten your left leg while also dropping your right arm toward the ground above your head. Alternate opposite arm and opposite leg for 10 repetitions on each side.



Exercise 2: Hip extension/standing kickback

Start by standing near a wall with feet shoulder width apart. Place your hand on the wall if you need help with balance. Maintain an upright posture and level hips. Extend one leg backwards until you feel your gluteals contract. Hold for a few seconds and then release back to the standing position. Alternate legs and repeat for 15 times on each leg.



Exercise 3: Donkey kick

Get into the four-point kneeling position with your hands under your shoulders and knees under your hips. Find a neutral spine and brace your abdominals. Extend one of your legs backward while keeping your knee bent. Only lift as high as your upper leg becoming parallel with your spine. It is important to brace your abdominals to keep your back from arching. You should feel your gluteal muscles contracting as you are performing this exercise. Hold for a few seconds and then release. Alternate legs and repeat for 20 repetitions on both legs.



Exercise 4: Glute bridge hold

Lie down on your back with your knees bent at a 90° angle and feet shoulder width apart on the floor. Brace your abdominals and squeeze your glutes to pull your lower back off of the floor. Stop when your shoulders, hips, and knees are in a straight line. The only thing that should still be in contact with the floor is your head, shoulder, and feet. Hold for five seconds and then return to the ground. Repeat 15 times.



3. Functional Training

Goal: to retrain the nervous system and muscles to work together to use the right muscles at the right time for good posture

Exercise 1: Sitting/standing properly

In lordosis, the pelvis is anteriorly tilted. Therefore, it is important to learn how to sit with a neutral pelvis. In order to do this, the ribs must be positioned correctly. Begin by placing your hand on the front of your lower rib cage and guide your ribcage down and backward. You should feel the arch in your back decrease and might even feel a stretch depending on how tight you are. Practice this position whenever you are sitting so that you can work on retraining your muscles.

Kyphosis

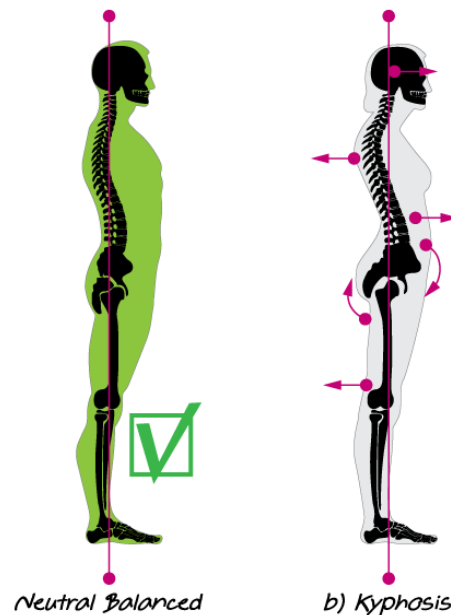


Figure 5. Neutral Spine compared to Kyphotic Spine. Hui, A. (2018, September 28). Take these Small Steps to Improve your Posture in the Office. Retrieved from <https://www.olympiabenefits.com/blog/good-posture-why-is-it-important-how-can-you-improve-in-the-office>.

To recognize kyphotic posture, it is important to identify the position of the body structures. Figure 5 compares a neutral spine to a kyphotic spine. In kyphosis, the head is protracted or moved forward. The upper part of the cervical spine is extended displaying hyperlordosis and the lower part is flexed. The scapulae are abducted or moved laterally while the shoulders are protracted or moved forward. The thoracic spine is in a state of increased flexion which causes the chest and sternum to be tilted downward. The lumbar spine is either neutral or in hyperlordosis. Depending on the lumbar spine position, the pelvis, hip joints, knee joints, and ankle joints are all neutral or flexed (Czaprowski, 2018). Kyphosis, also referred to as hunchback, is oftentimes associated with forward head posture and rounded shoulders as well (Wong, 2016b).

Muscles in Kyphotic Posture				
Muscle	Lengthened	Shortened	Hypoactive	Hyperactive
Abdominals		x		x
Anterior intercostals		x		x
Erector spinae	x			x
Gluteal muscles	x		x	
Hamstrings	x			x
Iliacus		x	x	
Latissimus dorsi	x			x
Pectoralis minor and major		x		x
Psoas		x		x
Quadratus lumborum		x	x	
Rhomboideus major and minor	x		x	
Scaleni		x		x
Serratus anterior	x		x	
Sternocleidomastoid		x		x
Suboccipital		x		x
Trapezius	x		x	

Table 2. Functional Characteristics of Muscles in the Kyphotic Posture.

The position of the different body parts affects which muscles are lengthened, shortened, hypoactive and hyperactive (Table 2). The latissimus dorsi may only be shortened near the insertion because of the shoulder protraction and internal rotation, and the medial part of the muscle may be lengthened because of the increased flexion in the thoracic spine. The abdominal muscles are shortened as a result of the chest tilting (Czaprowski, 2018). The other tight muscles that pull the upper back into a rounded position are the pectoralis major and minor and the anterior intercostals. The weak muscles are the erector spinae (Wong, 2016b).

The causes of kyphosis are similar to that of lordosis. Having a desk job that requires a lot of computer work promotes a hunchback posture due to the position the body sits in while at work. Another cause of kyphosis could be psychological. A person's confidence could affect the way they hold their body. Therefore, people with low self confidence tend to have a posture with rounded shoulders whereas people with high self confidence tend to hold themselves upright. Another cause could be excessively performing sit-ups or crunches which

causes shortening of the abdominal muscles and due to the kinetic chain, also pulls the upper back forward. Finally, sleeping on the side of the body in the fetal position could also lead to kyphosis in the upper back (Wong, 2016b).

A wall test can be utilized to determine kyphosis. Begin the test by standing with the back against a wall. Attempt to place all of the spine against the wall. If a large part of the upper spine is away from the wall and not able to lie flat against it, this is an indicator of kyphosis. It is important for the lower back not to move into excessive lordosis in order for the upper back to touch the wall (Wong, 2016b). If one is unsure of diagnosis, it is always best to consult an individual's doctor.

For correcting kyphosis, it is important to address the forward head posture and the rounded shoulders as well as the rounding of the thoracic spine. The tight muscles addressed in someone with kyphotic posture are the pectoralis major and minor, upper abdominals, and anterior intercostals. These muscles need to be stretched and loosened. The weak muscles that need to be addressed are the thoracic erector spinae group. They need to be strengthened in order to correct this posture (Wong, 2016b).

Corrective Exercises for Kyphosis

1. Releases and Stretches

Goal: to loosen the tight muscles so that they are able to be in the proper position for upright posture

Exercise 1: Chest release

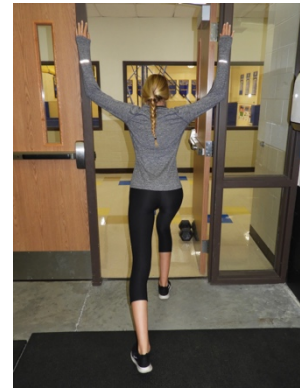
Lay on your stomach on the floor. Place a massage ball, or ball of similar softness and size under your subclavius and pectoralis major and minor. Apply your body



weight to the ball so that you can feel the ball massaging your muscles as you move in it in a circular motion over these muscles. If you feel yourself tensing up, adjust the amount of body weight you are applying to the ball. Do this for two minutes on each side of the body.

Exercise 2: Chest stretch

Find a door frame and open the door. Place both hands on either side of the frame with arms extended above the head. Place one foot in front of the other as if you were lunging while keeping your head, neck, and spine in line with your pelvis like you would in a hip hinge. Pull your shoulders back and down. Be careful not to arch your lower back. You should feel a stretch in your anterior shoulders and chest. Hold for 30 seconds and then release. Repeat three times.



Exercise 3: Abdominal stretch (cobra)

Lie on your stomach on the floor. Keeping your thighs and hips on the floor use your arms to raise your upper body and torso up off of the floor. You should feel a stretch in your abdominal region. Hold for 30 seconds and lower yourself back to the ground. Repeat 3 times. Do not over arch your back if you have any lower back pain.



2. Joint Mobilization

Goal: to free up the joints that are stuck in a flexed position

Exercise 1: Thoracic rotation

Sit upright in a chair with your feet flat on the floor. Twist your torso to one side as if you were looking behind you and grab the side of the chair. Keep your hips and lower torso facing forward. You should feel the stretch in your upper back, not your lower back. Hold this position for 30 seconds, release, and repeat on the other side.



Exercise 2: Thoracic extension

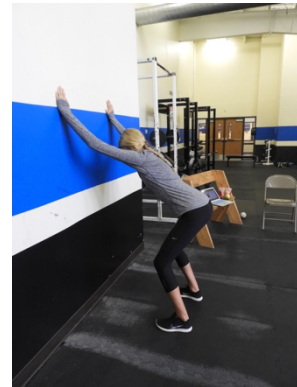
Lay on your back on the floor and place a foam roller, or a rolled up towel, between your upper back and the floor. Allow your shoulder to fall toward the floor



creating an arch in your upper back. Do not allow your ribcage to lift up excessively. If it does, it may mean you are arching your lower back and you do not want to do this. This stretch is intended to isolate the upper back only. Hold the stretch for 30 seconds and repeat 3 times.

Exercise 3: Wall lean

Stand facing a wall with your feet shoulder width apart. Place both hands above your head on the wall in front of you. Shift your body weight into your hands by bending your knees and leaning forward while keeping your head, spine and hips in a straight line. Be sure to also brace your abdominals which will keep your lower back from arching. Hold for 30 seconds and repeat 3 times.



3. Strengthening Exercises

Goal: to strengthen the weak muscles that are needed to keep an upright posture

Exercise 1: Superman

This exercise activates the lower back muscles. Begin by lying on your stomach. Stretch your arms out in front of you. Lift your arms and chest slightly off the floor while keeping the muscles of your lower back relaxed. Hold for a few seconds and return to the floor. You should feel the muscles between your shoulder blades tense up and then release. Repeat 20 times.



Exercise 2: Bird dog

Place your hands and knees on the floor in a four-point kneeling position. Knees should be directly under the hips and hands should be directly under the shoulders. Maintain a neutral spine and brace your abdominals. Simultaneously, lift your right arm and left leg to parallel with your spine. Hold for a few seconds and then return back to the four-point stance. Repeat with the opposite arm and leg. Complete 20 repetitions on each side.



4. Forward Head Posture

Goal: to loosen the tight muscles, improve mobility of the neck, strengthen the weak muscles of the neck

Exercise 1: Suboccipital release

Lie down flat on your back and place your massage ball, or any other ball of similar size, under your neck at the base of the skull. Rotate your head from side to side to massage the muscles of the neck. Do this on both sides of the neck (right and left) for 2 minutes on each side.



Exercise 2: Sternocleidomastoid release

Locate the sternocleidomastoid muscles on each side of your neck. They should be the most prominent muscle that you can feel on either side of the neck. Using a pinch grip, gently massage the muscle for one minute on each side. Be careful not to massage too hard because there are other sensitive structures in the neck that can be easily damaged.



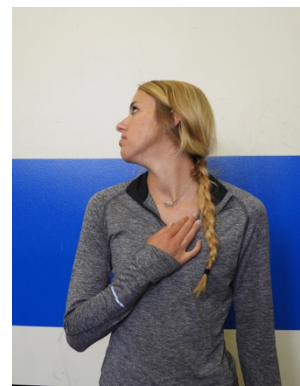
Exercise 3: Suboccipital stretch

Standing up straight or sitting up straight in a chair, gently tuck your chin in toward your neck. Look down and place your hand on the back of your head. Gently pull your head down until you feel a stretch in the back of your neck. Be careful not to pull too hard, just enough to feel the stretch. Hold for 30 seconds and repeat 3 times.



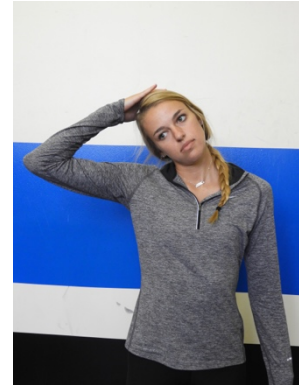
Exercise 4: Anterior scalene

Standing up straight or sitting up straight in a chair, look up and rotate your head to one side as if you were looking over your shoulder. Place your hand on the collar bone of the opposite side that you rotated your head to. You should feel a stretch along the side of your neck. Hold for 30 seconds and release. Repeat 2 times on each side.



Exercise 5: Middle scalene stretch

Standing or sitting up straight, tilt your head to the side trying to get your ear to your shoulder. Place your hand on the opposite side of your head and gently apply pressure to try to push your ear closer to your shoulder. Apply only enough to pressure to feel the stretch in your neck. Hold for 30 seconds, release, and alternate sides for two times on each side.



Exercise 6: Chin tucks

While sitting up straight in a chair, tuck your chin in toward your neck like you are making a double chin. You should feel a stretch in the back of your neck as if you were lengthening your neck. Make sure your eyes and jaw stay level and that you are moving your head horizontally backward, not up and down. Hold for five seconds and repeat 30 times.



Exercise 7: Chin tucks against gravity

This exercise is a progression of the last one and is for those who have been doing the chin tucks and they have become too easy. Lay on your stomach with your head hanging off the edge of a bed. Make sure your head is in line with your spine and complete the same chin tuck as before. This time, you have to work to stabilize your head and neck while working against gravity. Hold for five seconds, release, and repeat 30 times.



Exercise 8: Chin nods

This exercise is similar to a chin tuck, but places more emphasis on strengthening the deep neck flexors at the front of your neck. Lay down on your back with a thin pillow supporting your neck. Do the same chin tuck as before but before releasing, simply move your head up and down slightly, as if saying "yes." You should feel a slight stretch in the back of your neck as well as the front of neck as the muscles are moving. After the nod, release the tuck, and repeat 30 times.



Exercise 9: Chin nods against gravity

This again is a progression of the chin nod for those who are ready for a more advanced exercise. Lay on your back with your head hanging over the bed. Ensure that your head, neck, and spine are in a straight line. Perform the same chin tuck, chin nod sequence as before. This time you are working against gravity. Your neck muscles should be relaxed during this exercise. If you find that you are tensing your neck excessively, stop this exercise and go back to the chin nods with your head resting on the bed.



5. Rounded Shoulders

Goal: to loosen the tight muscles that are pulling the shoulders forward and strengthen the weak muscles so the shoulders can be re-positioned correctly

Exercise 1: Chest release

Lay on your stomach on the floor. Place a massage ball, or ball of similar softness and size under your subclavius and pectoralis major and minor. Apply your body weight to the ball so that you can feel the ball massaging your muscles as you move in it in a circular motion over these muscles. If you feel yourself tensing up, adjust the amount of body weight you are applying to the ball. Do this for two minutes on each side of the body.



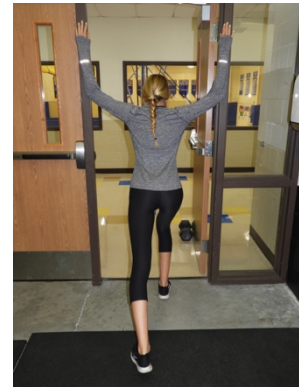
Exercise 2: Side release

Lay on the floor on your side with your arm closest to the floor above your head as if you were laying your ear on your arm. Place the massage ball under your armpit to roll out your latissimus dorsi and serratus anterior. Apply the appropriate amount of body weight to the ball, using your other arm for balance and support. Roll your body in an up and down motion to massage the muscles. Do this for two minutes and repeat on the other side of the body.



Exercise 3: Chest stretch

Find a door frame and open the door. Place both hands on either side of the frame with arms extended above the head. Place one foot in front of the other as if you were lunging while keeping your head, neck, and spine in line with your pelvis like you would in a hip hinge. Pull your shoulders back and down. Be careful not to arch your lower back. You should feel a stretch in your anterior shoulders and chest. Hold for 30 seconds and then release. Repeat three times.



Exercise 4: Lateral stretch

Stand perpendicular to a wall. Place the arm closest to wall on the wall for support. Place your outside leg behind the leg closest to the wall. Stretch your outside arm up over your head and lean away from the wall to create “c” shape with your body. Let your upper body take the weight of your body and use your body weight to feel the stretch on the side of your torso. Hold for 30 seconds and repeat on the other side.



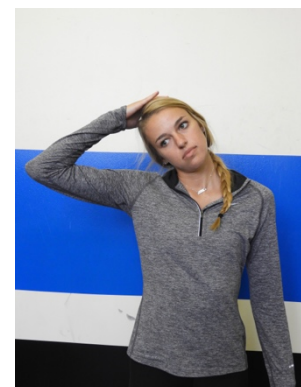
Exercise 5: Front shoulder stretch

With both of your hands on the seat of a chair, your knees bent at 90° in front of you, and your feet flat on the floor, allow your body to move down to the floor as low as possible similar to if you were doing a tricep dip. Make sure to keep your shoulder blades squeezed together and do not allow your shoulders to protract forward or elevate upward. You want to keep a neutral spine. Additionally, do not allow your elbows to flare out. You should feel this stretch at the front of your shoulders. Hold for 30 seconds and repeat three times.



Exercise 6: Upper trapezius stretch

Standing up straight or sitting up straight in a chair, pull your shoulders back and down. Tilt your head to one side as if you were putting your ear on your shoulder. Use your hand to gently pull your head closer to your shoulder until you feel the stretch in the side of your neck. Hold for 30 seconds and repeat on the other side.



Exercise 7: External rotation

Stand with your heels, butt, back, and head touching a wall. Place your arms at your side and bend your elbows to 90° so that your hands are out in front of you. Externally rotate at your shoulder by moving your hands back toward the wall while keeping your elbows touching the wall. Then slowly return to the starting position. Repeat this 20 times.

**Exercise 8: Internal rotation stretch**

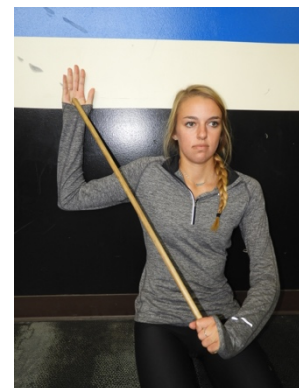
Place both of your hands on your lower back, one on top of the other, with the back of your hands touching your back. Pull your elbows back shoulder blades together. Hold for 30 seconds, release, and repeat 3 times.

**Exercise 9: Penguin Stretch**

Stand with your heels, butt, back, and head touching a wall. Place your fingertips on your shoulders and touch your elbows to the wall. Slowly, lift your arms as if you were trying to touch the back of your hands to your ears. Stop if your elbows come off the wall at any point. Then, return to the starting position. Repeat this 20 times.

**Exercise 10: Wall slides**

Sit with your butt, back, and head against a wall with your legs extended out in front of you. Place one arm on the wall with your elbow and back of the hand touching the wall. Using your stick to guide you, slide your arm up the wall until it is fully extended. Try not to lean to the opposite side, but sit upright keeping a good posture. Slowly lower back down and repeat 20 times. Repeat on the other arm 20 times as well.



Exercise 11: Cactus stretch

Stand with your heels, butt, back, and head touching a wall. Place the back of your hands on the wall and create a “w” shape with your arms against the wall. This is similar to the wall slides. However, this exercise is bilateral whereas the wall slides were unilateral. Slowly, lift your arms above your head keeping contact with the wall until they are fully extended overhead and then slowly move them back down. Repeat movement 20 times.



Exercise 12: Thoracic extension

Lay on your back on the floor and place a foam roller, or a rolled up towel, between your upper back and the floor. Allow your shoulder to fall toward the floor creating an arch in your upper back. Do not allow your ribcage to lift up excessively. If it does, it may mean you are arching your lower back and you do not want to do this. This stretch is intended to isolate the upper back only. Hold the stretch for 30 seconds and repeat 3 times.



Flat Back

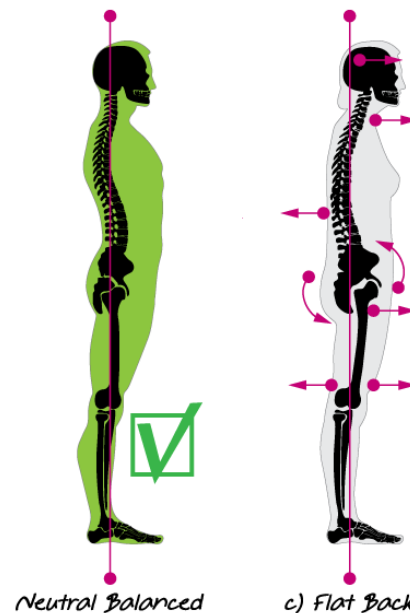


Figure 6. Neutral Spine compared to Flat Back Spine. Hui, A. (2018, September 28). Take these Small Steps to Improve your Posture in the Office. Retrieved from <https://www.olympiabenefits.com/blog/good-posture-why-is-it-important-how-can-you-improve-in-the-office>.

To recognize flat back posture, it is important to identify the position of the body structures. Figure 6 compares a neutral spine to a flat back spine. In flat back, the head can be either neutral or protracted. Just as in kyphosis, the upper part of the cervical spine is extended displaying hyperlordosis and the lower part is flexed in flat back posture (Czaprowski, 2018). The upper part of the thoracic spine displays increased flexion and the lower part is straight (Claus, 2014). The lumbar spine is flexed. The pelvis is posteriorly tilted causing the hip joints to be extended (Wong, 2017b). The knee and ankle joints remain neutral (Czaprowski, 2018). Put simply, there is a lack of curves in the spine. Usually, flat back is caused by both the upper spine attempting to position the head and shoulders in an upright position while the shoulders are

still rounded and by the pelvis being posteriorly tilted due to sitting in a slouched position (Wong, 2017b).

The position of the different body parts affects which muscles are lengthened, shortened, hypoactive and hyperactive (Table 3). Flat back is characterized by having shortened and hyperactive hamstrings, abdominal muscles, and gluteal muscles. It is also characterized by having lengthened and hypoactive lumbar paraspinals, iliacus, and psoas (Czaprowski, 2018; Wong, 2017b).

Muscles in Flat Back Posture				
Muscle	Lengthened	Shortened	Hypoactive	Hyperactive
Abdominals		x		x
Erector spinae	x			x
Gluteal muscles		x	x	
Hamstrings		x		x
Iliacus	x		x	
Latissimus dorsi		x		x
Lumbar paraspinals	x		x	
Pectoralis major and minor		x		x
Psoas	x			x
Quadratus lumborum	x		x	
Rhomboideus major and minor		x		x
Scaleni		x		x
Sternocleidomastoid		x		x
Suboccipital		x		x
Trapezius		x		x

Table 3. Functional Characteristics of Muscles in the Flat-Back Posture.

To test for a flat back, view the body in the sagittal plane or from the side. If the back creates a straight line from the top of the shoulders to the butt, it is a good indication of flat back. There should be natural curves in the back. Another way to test for flat back is to place one finger on the hip bone at the front and one finger on the hip bone at the back. If the front finger is higher, this indicates a posterior tilt (Wong, 2017b).

Just like in any posture deviation, there is a muscle imbalance and that imbalance can cause other issues. Having a flat back posture inhibits the spine's ability to absorb and distribute mechanical stress evenly throughout the body. This causes some muscles to work harder to help stabilize and move the spine. Two of the key characteristics of flat back posture that should be addressed in rehabilitation are the flat thoracic spine and the posterior pelvic tilt (Wong, 2017b).

Corrective Exercises for Flat Back

1. Flat Thoracic Spine

Goal: to regain the natural curve in the thoracic spine

Exercise 1: Thoracic paraspinals release

Obtain a small ball such as a massage ball, tennis ball, or lacrosse ball. Lay on your back and place the ball between your shoulder blade and spine underneath of you. Use your body weight to roll over the ball in a circular motion. Do this on both sides of spine for about 2 minutes on each side. Do not place the ball directly on the spine. It will hurt and could cause further injury.



Exercise 2: Thoracic flexion stretch

While sitting in a chair, place a foam roller in your lap. Fold your upper body over the foam roller and focus on bending the upper back as much as possible. The goal is not to stretch/put stress on the neck; the focus is the upper back. Hold for 30 seconds and take deep breaths to expand the area between your shoulder blades. Return to neutral spine and then repeat 3 times.



Exercise 3: Upper body rotation

Place your hands and knees on the floor in a four-point kneeling position. Knees should be directly under the hips and hands should be directly under the shoulders.



Maintain a neutral spine. Place one hand behind your head being careful not to pull on your neck. Brace your abdominals and twist your body to the side where the hand is on your head. Make sure to keep your hips neutral so that you isolate the thoracic region. Lower back down to where shoulders are level. Repeat 20 times on the same side. Then switch sides.

Exercise 4: Intersegment cat/cow

Get into the four-point kneeling position again. Ensure that your spine is neutral. Starting from the neck, begin to round your spine down one vertebra at a time until you reach your mid-back. Then reverse the movements back to the beginning. Make sure you are going to slow and really emphasizing the curving where your spine is the flattest. Repeat 20 times.



2. Flat lumbar spine

Goal: to correct posterior pelvic tilt which will help regain the natural curve of the lumbar spine

Exercise 1: Hamstring release

Obtain a small ball such as a massage ball, tennis ball, or lacrosse ball. Starting from the top of your hamstring muscles near the gluteal region, position your body over the ball. Using your body weight to apply pressure to the hamstring muscle, gradually move over the ball to massage your hamstring muscle working your way down to the back of your knee. Do this for about 2 minutes per leg.



Exercise 2: Hamstring stretch

In a standing position, place one leg straight in front of you. Hinge forward toward the leg in front at the hips while keeping your back straight. You should feel a stretch in the lower part of your hamstring (left). To stretch the upper hamstring, repeat the same movements but have a slight bend in the knee of the leg that is out front (right). Complete stretch on both legs holding for 30 seconds



at a time. Repeat 2-3 times per leg.

Exercise 3: Cobra

Lie on your stomach on the floor. Keeping your thighs and hips on the floor use your arms to raise your upper body and torso up off of the floor. You should feel a stretch in your abdominal region. Hold for 30 seconds and lower yourself back to the ground. Repeat 3 times. Do not over arch your back if you have any lower back pain.



Exercise 4: Sitting hip flexion

Sit on the edge of chair with feet flat on the floor and knees at a 90° angle. Make sure the spine is neutral as it would be in good posture. Lift one knee as high as possible keeping that 90° angle. Hold for 5 seconds and then move foot back to the floor. Alternate knees and repeat 10 times on each side.



Exercise 5: Superman

This exercise activates the lower back muscles. Begin by lying on your stomach. Stretch your arms out in front of you. At the same time, lift your arms and legs off the floor creating a slight bend in your lower back. Hold for a few seconds and return to the floor. Repeat 20 times.



Exercise 6: Pelvic tilt

Begin in the four-point kneeling position with a neutral spine and hips. Tilt your pelvis forward which should cause your back to arch. Hold for a few seconds and return to neutral. Repeat 20 times.

This exercise can also be done in a sitting position. Begin by sitting neutral in a chair. Tilt the pelvis forward and observe the arch in your back. Hold for a few seconds and return to neutral. Repeat 20 times. This can also be done throughout the day at your work desk, when standing in line, etc. to try to correct your muscle memory.



3. Forward Head Posture

Goal: to loosen the tight muscles, improve mobility of the neck, strengthen the weak muscles of the neck

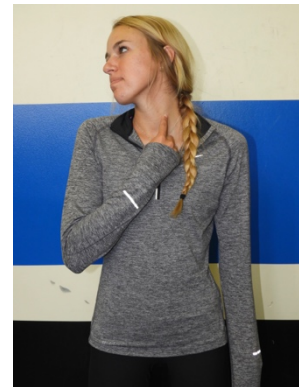
Exercise 1: Suboccipital release

Lie down flat on your back and place your massage ball, or any other ball of similar size, under your neck at the base of the skull. Rotate your head from side to side to massage the muscles of the neck. Do this on both sides of the neck (right and left) for 2 minutes on each side.



Exercise 2: Sternocleidomastoid release

Locate the sternocleidomastoid muscles on each side of your neck. They should be the most prominent muscle that you can feel on either side of the neck. Using a pinch grip, gently massage the muscle for one minute on each side. Be careful not to massage too hard because there are other sensitive structures in the neck that can be easily damaged.



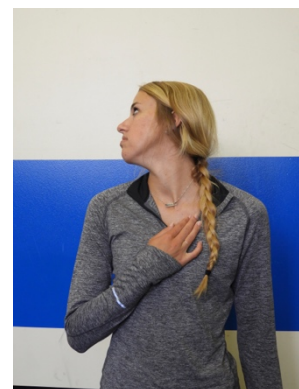
Exercise 3: Suboccipital stretch

Standing up straight or sitting up straight in a chair, gently tuck your chin in toward your neck. Look down and place your hand on the back of your head. Gently pull your head down until you feel a stretch in the back of your neck. Be careful not to pull too hard, just enough to feel the stretch. Hold for 30 seconds and repeat 3 times.



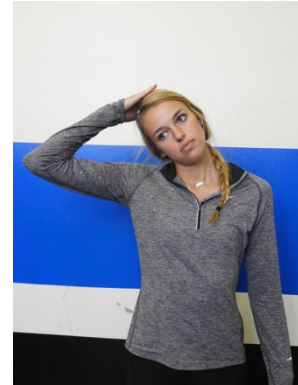
Exercise 4: Anterior scalene

Standing up straight or sitting up straight in a chair, look up and rotate your head to one side as if you were looking over your shoulder. Place your hand on the collar bone of the opposite side that you rotated your head to. You should feel a stretch along the side of your neck. Hold for 30 seconds and release. Repeat 2 times on each side.



Exercise 5: Middle scalene stretch

Standing or sitting up straight, tilt your head to the side trying to get your ear to your shoulder. Place your hand on the opposite side of your head and gently apply pressure to try to push your ear closer to your shoulder. Apply only enough to pressure to feel the stretch in your neck. Hold for 30 seconds, release, and alternate sides for two times on each side.

**Exercise 6: Chin tucks**

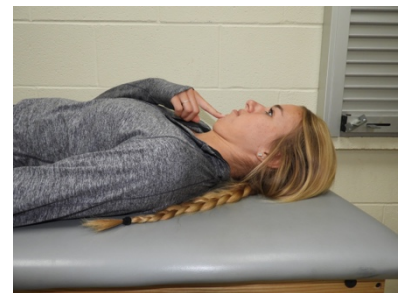
While sitting up straight in a chair, tuck your chin in toward your neck like you are making a double chin. You should feel a stretch in the back of your neck as if you were lengthening your neck. Make sure your eyes and jaw stay level and that you are moving your head horizontally backward, not up and down. Hold for five seconds and repeat 30 times.

**Exercise 7: Chin tucks against gravity**

This exercise is a progression of the last one and is for those who have been doing the chin tucks and they have become too easy. Lay on your stomach with your head hanging off the edge of a bed. Make sure your head is in line with your spine and complete the same chin tuck as before. This time, you have to work to stabilize your head and neck while working against gravity. Hold for five seconds, release, and repeat 30 times.

**Exercise 8: Chin nods**

This exercise is similar to a chin tuck, but places more emphasis on strengthening the deep neck flexors at the front of your neck. Lay down on your back with a thin pillow supporting your neck. Do the same chin tuck as before but before releasing, simply move your head up and down slightly, as if saying “yes.” You should feel a slight stretch in the back of your neck as well as the front of neck as the muscles are moving. After the nod, release the tuck, and repeat 30 times.



Exercise 9: Chin nods against gravity

This again is a progression of the chin nod for those who are ready for a more advanced exercise. Lay on your back with your head hanging over the bed. Ensure that your head, neck, and spine are in a straight line. Perform the same chin tuck, chin nod sequence as before. This time you are working against gravity. Your neck muscles should be relaxed during this exercise. If you find that you are tensing your neck excessively, stop this exercise and go back to the chin nods with your head resting on the bed.



4. Rounded Shoulders

Goal: to loosen the tight muscles that are pulling the shoulders forward and strengthen the weak muscles so the shoulders can be re-positioned correctly

Exercise 1: Chest release

Lay on your stomach on the floor. Place a massage ball, or ball of similar softness and size under your subclavius and pectoralis major and minor. Apply your body weight to the ball so that you can feel the ball massaging your muscles as you move in it in a circular motion over these muscles. If you feel yourself tensing up, adjust the amount of body weight you are applying to the ball. Do this for two minutes on each side of the body.



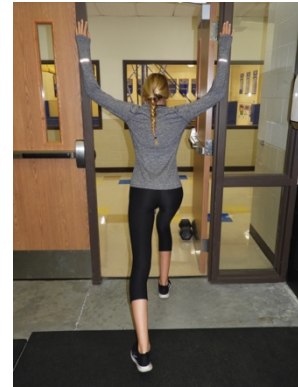
Exercise 2: Side release

Lay on the floor on your side with your arm closest to the floor above your head as if you were laying your ear on your arm. Place the massage ball under your armpit to roll out your latissimus dorsi and serratus anterior. Apply the appropriate amount of body weight to the ball, using your other arm for balance and support. Roll your body in an up and down motion to massage the muscles. Do this for two minutes and repeat on the other side of the body.



Exercise 3: Chest stretch

Find a door frame and open the door. Place both hands on either side of the frame with arms extended above the head. Place one foot in front of the other as if you were lunging while keeping your head, neck, and spine in line with your pelvis like you would in a hip hinge. Pull your shoulders back and down. Be careful not to arch your lower back. You should feel a stretch in your anterior shoulders and chest. Hold for 30 seconds and then release. Repeat three times.



Exercise 4: Lateral stretch

Stand perpendicular to a wall. Place the arm closest to wall on the wall for support. Place your outside leg behind the leg closest to the wall. Stretch your outside arm up over your head and lean away from the wall to create “c” shape with your body. Let your upper body take the weight of your body and use your body weight to feel the stretch on the side of your torso. Hold for 30 seconds and repeat on the other side.



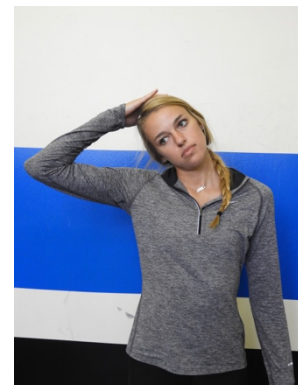
Exercise 5: Front shoulder stretch

With both of your hands on the seat of a chair, your knees bent at 90° in front of you, and your feet flat on the floor, allow your body to move down to the floor as low as possible similar to if you were doing a tricep dip. Make sure to keep your shoulder blades squeezed together and do not allow your shoulders to protract forward. You want to keep a neutral spine. Additionally, do not allow your elbows to flare out. You should feel this stretch at the front of your shoulders. Hold for 30 seconds and repeat three times.



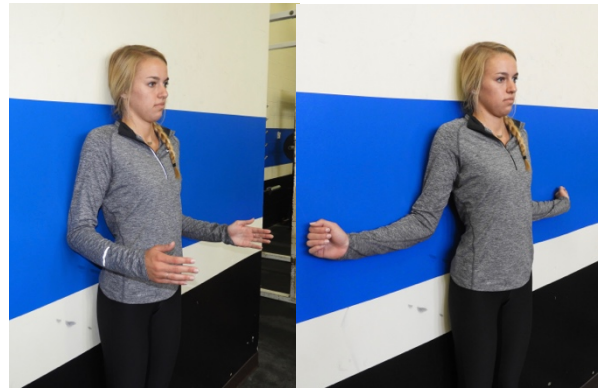
Exercise 6: Upper trapezius stretch

Standing up straight or sitting up straight in a chair, pull your shoulders back and down. Tilt your head to one side as if you were putting your ear on your shoulder. Use your hand to gently pull your head closer to your shoulder until you feel the stretch in the side of your neck. Hold for 30 seconds and repeat on the other side.



Exercise 7: External rotation

Stand with your heels, butt, back, and head touching a wall. Place your arms at your side and bend your elbows to 90° so that your hands are out in front of you. Externally rotate at your shoulder by moving your hands back toward the wall while keeping your elbows touching the wall. Then slowly return to the starting position. Repeat this 20 times.

**Exercise 8: Internal rotation stretch**

Place both of your hands on your lower back, one on top of the other, with the back of your hands touching your back. Pull your elbows back shoulder blades together. Hold for 30 seconds, release, and repeat 3 times.

**Exercise 9: Penguin Stretch**

Stand with your heels, butt, back, and head touching a wall. Place your fingertips on your shoulders and touch your elbows to the wall. Slowly, lift your arms as if you were trying to touch the back of your hands to your ears. Stop if your elbows come off the wall at any point. Then, return to the starting position. Repeat this 20 times.

**Exercise 10: Wall slides**

Sit with your butt, back, and head against a wall with your legs extended out in front of you. Place one arm on the wall with your elbow and back of the hand touching the wall. Using your stick to guide you, slide your arm up the wall until it is fully extended. Try not to lean to the opposite side, but sit upright keeping a good posture. Slowly lower back down and repeat 20 times. Repeat on the other arm 20 times as well.



Exercise 11: Cactus stretch

Stand with your heels, butt, back, and head touching a wall. Place the back of your hands on the wall and create a “w” shape with your arms against the wall. This is similar to the wall slides. However, this exercise is bilateral whereas the wall slides were unilateral. Slowly, lift your arms above your head keeping contact with the wall until they are fully extended overhead and then slowly move them back down. Repeat movement 20 times.



Exercise 12: Thoracic extension

Lay on your back on the floor and place a foam roller, or a rolled up towel, between your upper back and the floor. Allow your shoulder to fall toward the floor creating an arch in your upper back. Do not allow your ribcage to lift up excessively. If it does, it may mean you are arching your lower back and you do not want to do this. This stretch is intended to isolate the upper back only. Hold the stretch for 30 seconds and repeat 3 times.



Sway Back

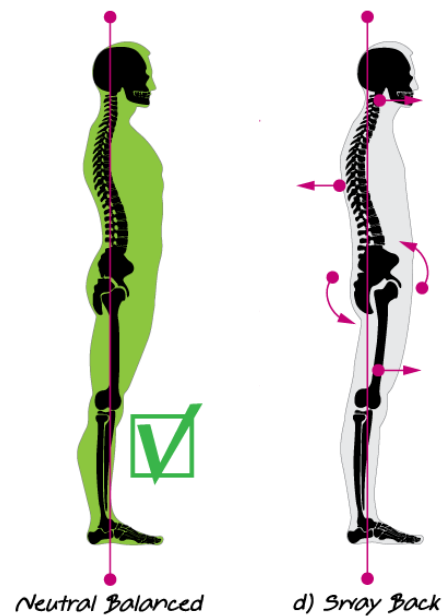


Figure 7. Neutral Spine compared to Sway Back Spine. Hui, A. (2018, September 28). Take these Small Steps to Improve your Posture in the Office. Retrieved from <https://www.olympiabenefits.com/blog/good-posture-why-is-it-important-how-can-you-improve-in-the-office>.

To recognize sway-back posture, it is important to identify the position of the body structures. Figure 7 compares a neutral spine to a sway back spine. The position of the upper body is very similar to the characteristics of flat back. The head is in a protracted position. The upper part of the cervical spine is extended and the lower part is flexed. The upper part of the thoracic spine is in increased flexion and the lower part is normal. The upper part of the lumbar spine is in flexion while the lower part is in increased extension. The pelvis is shifted anteriorly decreasing the anterior tilt which causes the hip joints to be extended. The knee joints are either neutral or hyperextended. The ankle joints are either neutral or plantar flexed (Czaprowski, 2018).

Muscles in Sway Back Posture				
Muscle	Lengthened	Shortened	Hypoactive	Hyperactive
Abdominal muscles	x			x
Erector spinae	x		x	
Gluteal muscles		x	x	
Hamstrings		x		x
Iliacus	x		x	
Latissimus dorsi	x			x
Pectoralis minor and major		x		x
Psoas	x			x
Quadratus lumborum		x	x	
Rhomboideus major and minor	x		x	
Scaleni		x		x
Serratus anterior	x		x	
Sternocleidomastoid		x		x
Suboccipital		x		x
Trapezius	x		x	

Table 4. Functional Characteristics of Muscles in the Sway-Back Posture.

The position of the different body parts affects which muscles are lengthened, shortened, hypoactive and hyperactive (Table 4) (Czaprowski, 2018). A key characteristic of sway back posture is tight and overactive hamstrings which causes the hips to be moved forward. This then causes elongated and weak hip flexors, weak gluteal muscles, anterior rotation of the femoral head, weak external oblique, short internal oblique, and over-active muscles in the thoraco-lumbar region (Wong, 2017c). All of this together, leads to upper cross syndrome (Page, 2014).

When trying to correct sway back posture with rehabilitation exercises and stretches, it is important to note the things that the individual should avoid. First, stretching the hip flexor group should be avoided. The hip flexors, such as the psoas and iliacus, are already in a lengthened position, therefore, stretching them will make the situation worse by elongating them even further. Second, a person with sway back posture should avoid sleeping on their

stomach, a position that encourages sway posture due to how the body lays. Continual sleeping on the stomach will encourage the muscles to adapt to the new position, and over time, the body will automatically move into this position as the new normal (Wong, 2017c). This relates to muscle memory (Page, 2014). Thirdly, just like for any posture deviation, a patient with bad posture should avoid sitting and standing with their bad posture. This might be hard at first because it is what the muscles automatically go to. However, the individual must be cognitively aware of the position of their body and work to change that by positioning their body into the correct posture. Lastly, a person with sway back posture should be careful not to over do abdominal crunches. A lot of the time with back issues, individuals are told to strengthen their abdominals. While this is true in most cases, it could actually make sway back posture worse. Abdominal crunches increase the dominance of the rectus abdominis which then leads to the curving of the upper back which is observed in sway back posture (Wong, 2017c).

In order to correct sway back posture, six goals must be observed: 1) release the tightness in the hamstrings, 2) strengthen the hip flexors, 3) strengthen the gluteal muscles, 4) strengthen the external obliques while decreasing the rectus abdominis dominance, 5) address upper cross syndrome, and 6) retrain the proper posture in functional position (Wong, 2017c).

Corrective Exercises for Sway Back

1. Hamstrings

Goal: to decrease hyperactivity and tightness in the hamstring muscles

Exercise 1: Hamstring release

Obtain a small ball such as a massage ball, tennis ball, or lacrosse ball. Starting from the top of your hamstring muscles near the gluteal region, position your body over the ball. Using your body weight to apply pressure to the hamstring muscle, gradually move over the ball to massage your hamstring muscle working your way down to the back of your knee. Do this for about 2 minutes per leg.



Exercise 2: Hamstring stretch

In a standing position, place one leg straight in front of you. Hinge forward toward the leg in front at the hips while keeping your back straight. You should feel a stretch in the lower part of your hamstring (left). To stretch the upper hamstring, repeat the same movements but have a slight bend in the knee of the leg that is out front (right). Complete stretch on both legs holding for 30 seconds at a time. Repeat 2-3 times per leg.



Exercise 3: Tibialis anterior release

A hyperactive, tight tibialis anterior also pulls the lower body forward due to the connected chains that the Janda approach describes (Page, 2014). For this release, obtain the ball that you used for the hamstring release and place it on the outside of your lower leg. Move your body so that the ball covers the whole front and side of the lower leg. Complete for approximately 2 minutes on each leg.



2. Hip Flexors

Goal: to strengthen the hip flexor muscles (psoas and iliacus)

Exercise 1: Sitting hip flexion

Sit on the edge of chair with feet flat on the floor and knees at a 90° angle. Make sure the spine is neutral as it would be



in good posture. Lift one knee as high as possible keeping that 90° angle. Hold for 5 seconds and then move foot back to the floor. Alternate knees and repeat 10 times on each side.

Exercise 2: Jack knife with exercise ball

This is a more advanced exercise for core strength and stability. Get into a pushup position with your hands on the floor and your feet on an exercise ball, legs fully extended. Ensure that your spine is neutral. Brace your abdominal muscles throughout the whole exercise. Bring your knees toward your chest. Hold for a few seconds and then slowly release. Repeat 15 times.



3. Gluteal Muscles

Goal: to strengthen the gluteal muscles

Exercise 1: Hip extension/standing kickback

Start by standing near a wall with feet shoulder width apart. Place your hand on the wall if you need help with balance. Maintain an upright posture and level hips. Extend one leg backwards until you feel your glutes contract. Hold for a few seconds and then release back to the standing position. Alternate legs and repeat for 15 times on each leg.



Exercise 2: Glute bridge hold

Lie down on your back with your knees bent at a 90° angle and feet shoulder width apart on the floor. Brace your abdominals and squeeze your glutes to pull your lower back off of the floor. Stop when your shoulders, hips, and knees are in a straight line. The only thing that should still be in contact with the floor is your head, shoulder, and feet. Hold for five seconds and then return to the ground. Repeat 15 times.



4. External Obliques

Goal: increase strength of external obliques and decrease dominance of rectus abdominis

Exercise 1: Side plank

This exercise can be done either on the knees or on the feet depending on your level of ability. Start on your knees, and if that is too easy, progress to your feet. Place your elbow directly below your shoulder and ensure that your spine is neutral and hips are stacked on top of one another. Brace your abdominals and lift your hips up off the ground still maintaining that neutral spine and hips. Your shoulders, hips, and knees or ankles should be in line with one another. Hold for 30 seconds. Then, repeat on the other side.



5. Thoracolumbar Junction

Goal: to release the muscles of the thoracolumbar junction

Exercise 1: Lower back release

Lie on your back on the floor with your knees bent and feet flat on the floor. Place a massage ball or ball of a similar size under your lower back. Your target muscles are the quadratus lumborum, erector spinae, and latissimus dorsi. Relax your body weight over the ball and move your body in a circular motion to target those areas. Be sure not to roll the ball right on your spine. Cover all the muscles on both sides of the spine for two minutes.



Exercise 2: Cobra

Lie on your stomach on the floor. Keeping your thighs and hips on the floor use your arms to raise your upper body and torso up off of the floor. You should feel a stretch in your abdominal region. Hold for 30 seconds and lower yourself back to the ground. Repeat 3 times. Do not over arch your back if you have any lower back pain.



6. Forward Head Posture

Goal: to loosen the tight muscles, improve mobility of the neck, strengthen the weak muscles of the neck

Exercise 1: Suboccipital release

Lie down flat on your back and place your massage ball, or any other ball of similar size, under your neck at the base of the skull. Rotate your head from side to side to massage the muscles of the neck. Do this on both sides of the neck (right and left) for 2 minutes on each side.



Exercise 2: Sternocleidomastoid release

Locate the sternocleidomastoid muscles on each side of your neck. They should be the most prominent muscle that you can feel on either side of the neck. Using a pinch grip, gently massage the muscle for one minute on each side. Be careful not to massage too hard because there are other sensitive structures in the neck that can be easily damaged.



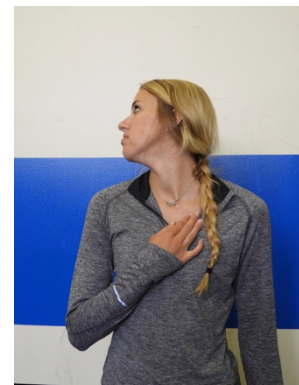
Exercise 3: Suboccipital stretch

Standing up straight or sitting up straight in a chair, gently tuck your chin in toward your neck. Look down and place your hand on the back of your head. Gently pull your head down until you feel a stretch in the back of your neck. Be careful not to pull too hard, just enough to feel the stretch. Hold for 30 seconds and repeat 3 times.



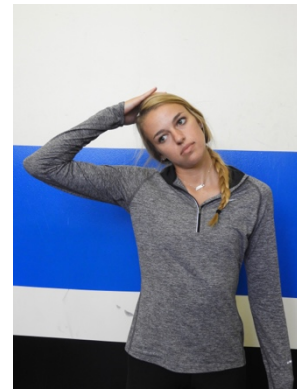
Exercise 4: Anterior scalene

Standing up straight or sitting up straight in a chair, look up and rotate your head to one side as if you were looking over your shoulder. Place your hand on the collar bone of the opposite side that you rotated your head to. You should feel a stretch along the side of your neck. Hold for 30 seconds and release. Repeat 2 times on each side.



Exercise 5: Middle scalene stretch

Standing or sitting up straight, tilt your head to the side trying to get your ear to your shoulder. Place your hand on the opposite side of your head and gently apply pressure to try to push your ear closer to your shoulder. Apply only enough pressure to feel the stretch in your neck. Hold for 30 seconds, release, and alternate sides for two times on each side.

**Exercise 6: Chin tucks**

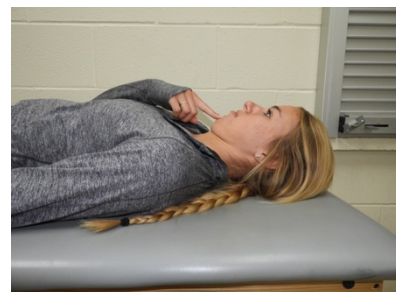
While sitting up straight in a chair, tuck your chin in toward your neck like you are making a double chin. You should feel a stretch in the back of your neck as if you were lengthening your neck. Make sure your eyes and jaw stay level and that you are moving your head horizontally backward, not up and down. Hold for five seconds and repeat 30 times.

**Exercise 7: Chin tucks against gravity**

This exercise is a progression of the last one and is for those who have been doing the chin tucks and they have become too easy. Lay on your stomach with your head hanging off the edge of a bed. Make sure your head is in line with your spine and complete the same chin tuck as before. This time, you have to work to stabilize your head and neck while working against gravity. Hold for five seconds, release, and repeat 30 times.

**Exercise 8: Chin nods**

This exercise is similar to a chin tuck, but places more emphasis on strengthening the deep neck flexors at the front of your neck. Lay down on your back with a thin pillow supporting your neck. Do the same chin tuck as before but before releasing, simply move your head up and down slightly, as if saying "yes." You should feel a slight stretch in the back of your neck as well as the front of neck as the muscles are moving. After the nod, release the tuck, and repeat 30 times.



Exercise 9: Chin nods against gravity

This again is a progression of the chin nod for those who are ready for a more advanced exercise. Lay on your back with your head hanging over the bed. Ensure that your head, neck, and spine are in a straight line. Perform the same chin tuck, chin nod sequence as before. This time you are working against gravity. Your neck muscles should be relaxed during this exercise. If you find that you are tensing your neck excessively, stop this exercise and go back to the chin nods with your head resting on the bed.



7. Rounded Shoulders

Goal: to loosen the tight muscles that are pulling the shoulders forward and strengthen the weak muscles so the shoulders can be re-positioned correctly

Exercise 1: Chest release

Lay on your stomach on the floor. Place a massage ball, or ball of similar softness and size under your subclavius and pectoralis major and minor. Apply your body weight to the ball so that you can feel the ball massaging your muscles as you move in it in a circular motion over these muscles. If you feel yourself tensing up, adjust the amount of body weight you are applying to the ball. Do this for two minutes on each side of the body.



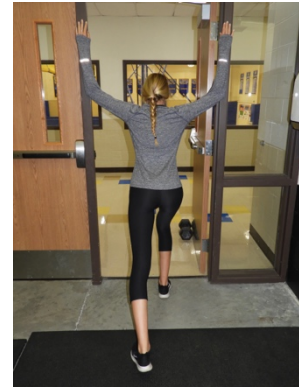
Exercise 2: Side release

Lay on the floor on your side with your arm closest to the floor above your head as if you were laying your ear on your arm. Place the massage ball under your armpit to roll out your latissimus dorsi and serratus anterior. Apply the appropriate amount of body weight to the ball, using your other arm for balance and support. Roll your body in an up and down motion to massage the muscles. Do this for two minutes and repeat on the other side of the body.



Exercise 3: Chest stretch

Find a door frame and open the door. Place both hands on either side of the frame with arms extended above the head. Place one foot in front of the other as if you were lunging while keeping your head, neck, and spine in line with your pelvis like you would in a hip hinge. Pull your shoulders back and down. Be careful not to arch your lower back. You should feel a stretch in your anterior shoulders and chest. Hold for 30 seconds and then release. Repeat three times.



Exercise 4: Lateral stretch

Stand perpendicular to a wall. Place the arm closest to wall on the wall for support. Place your outside leg behind the leg closest to the wall. Stretch your outside arm up over your head and lean away from the wall to create “c” shape with your body. Let your upper body take the weight of your body and use your body weight to feel the stretch on the side of your torso. Hold for 30 seconds and repeat on the other side.



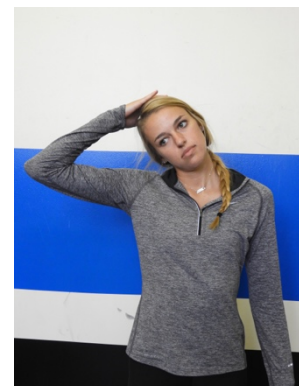
Exercise 5: Front shoulder stretch

With both of your hands on the seat of a chair, your knees bent at 90° in front of you, and your feet flat on the floor, allow your body to move down to the floor as low as possible similar to if you were doing a tricep dip. Make sure to keep your shoulder blades squeezed together and do not allow your shoulders to protract forward. You want to keep a neutral spine. Additionally, do not allow your elbows to flare out. You should feel this stretch at the front of your shoulders. Hold for 30 seconds and repeat three times.



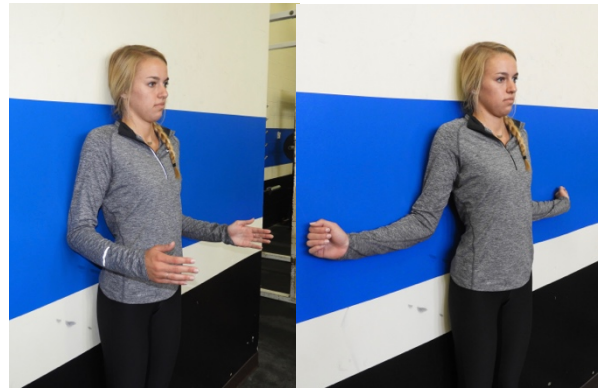
Exercise 6: Upper trapezius stretch

Standing up straight or sitting up straight in a chair, pull your shoulders back and down. Tilt your head to one side as if you were putting your ear on your shoulder. Use your hand to gently pull your head closer to your shoulder until you feel the stretch in the side of your neck. Hold for 30 seconds and repeat on the other side.



Exercise 7: External rotation

Stand with your heels, butt, back, and head touching a wall. Place your arms at your side and bend your elbows to 90° so that your hands are out in front of you. Externally rotate at your shoulder by moving your hands back toward the wall while keeping your elbows touching the wall. Then slowly return to the starting position. Repeat this 20 times.

**Exercise 8: Internal rotation stretch**

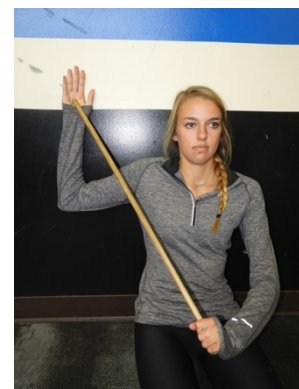
Place both of your hands on your lower back, one on top of the other, with the back of your hands touching your back. Pull your elbows back shoulder blades together. Hold for 30 seconds, release, and repeat 3 times.

**Exercise 9: Penguin Stretch**

Stand with your heels, butt, back, and head touching a wall. Place your fingertips on your shoulders and touch your elbows to the wall. Slowly, lift your arms as if you were trying to touch the back of your hands to your ears. Stop if your elbows come off the wall at any point. Then, return to the starting position. Repeat this 20 times.

**Exercise 10: Wall slides**

Sit with your butt, back, and head against a wall with your legs extended out in front of you. Place one arm on the wall with your elbow and back of the hand touching the wall. Using your stick to guide you, slide your arm up the wall until it is fully extended. Try not to lean to the opposite side, but sit upright keeping a good posture. Slowly lower back down and repeat 20 times. Repeat on the other arm 20 times as well.



Exercise 11: Cactus stretch

Stand with your heels, butt, back, and head touching a wall. Place the back of your hands on the wall and create a “w” shape with your arms against the wall. This is similar to the wall slides. However, this exercise is bilateral whereas the wall slides were unilateral. Slowly, lift your arms above your head keeping contact with the wall until they are fully extended overhead and then slowly move them back down. Repeat movement 20 times.



Exercise 12: Thoracic extension

Lay on your back on the floor and place a foam roller, or a rolled up towel, between your upper back and the floor. Allow your shoulder to fall toward the floor creating an arch in your upper back. Do not allow your ribcage to lift up excessively. If it does, it may mean you are arching your lower back and you do not want to do this. This stretch is intended to isolate the upper back only. Hold the stretch for 30 seconds and repeat 3 times.



8. Functional Training

Goal: to retrain the nervous system and muscles to work together to use the right muscles at the right time for good posture

Exercise 1: Standing properly

In sway back posture, the hips are positioned too far forward. Therefore, to correct this, begin by stacking the hips on top of the ankles by bending forward at the hips (aka hip hinge). Then, using your gluteal muscles, bring the upper body in line with the rest of the body. Slightly tilt your lower chest up, but do not go as far as to flare your ribs. Then, reposition your shoulders by rolling them back and down. Finally, elongate and retract your neck by pulling your chin into your body. It might feel weird, but that is because your body is not used to it. You must retrain your body to automatically go into this position in order for it to feel normal. Try to incorporate this throughout your day to day activities.

Exercise 2: Sit-to-stand properly

People with sway back posture tend to avoid bending forward when sitting or standing, causing their spine to become misaligned. To correct this, practice being forward at the hips – a hip hinge – before sitting down. A good cue to remember is “stick your bum out.” Then, before standing, you should also hip hinge. A cue for this one is “nose over toes.”

Conclusion

Posture is affected by activities of daily living, culture, environment, physical activity choices, physiology, emotions, and even the way an individual habitually stands and sits ultimately determines their mobility. Bad posture can lead to pain or pain can lead to bad posture which results in a never-ending cycle of muscle imbalance. It is necessary to understand that posture is not just a skeletal issue; it involves the bones, muscles, and nervous system.

The fitness industry is beginning to utilize injury prevention as part of exercise prescription. Practitioners in the fitness industry must be educated to recognize and assess different types of postural deviations in order to avoid loading dysfunctional joints and provide proper exercise prescriptions to improve posture.

The general population also must be educated to realize that the ability to move well and avoid postural dysfunction is a choice. Being able to recognize different types of posture and understand how to correct them can lead to better movement patterns and a pain-free lifestyle. It is always important to consult an individual's primary physician or a doctor if pain is ongoing or intense. The provided corrective exercises are a general guideline for use with each type of posture deviation. However, a doctor should always be consulted when pain is involved before beginning an exercise program.

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